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A COMPARISON OF THE EOCENE MOLLUSCA OF THE SOUTHEASTERN UNITED STATES AND WESTERN EUROPE IN RELATION TO THE DETERMINATION OF IDENTICAL FORMS.

BY ANGELO HEILPRIN.

The study of the fauna, whether extinct or living, of any country resolves itself into two distinct methods of investigation, the general and the comparative. In the general method we look upon an assemblage or community of animal forms as constituting an integral part of the country it characterizes, and we then consider it only in relation to that country and to itself the animal forms *inter se*). In the second or comparative method we no longer regard this community as constituting a whole or unit, but merely as a part of a more extensive community, and we now view it in the relation of a part to a whole. This comparative system of investigation, which, it will be manifest, involves a thorough general acquaintance with all or most extraneous faunæ as well as the one under special consideration, is one of great difficulty, and one that requires more than an ordinary amount of acumen in its pursuit, for in the broad facts of geographical distribution are connected some of the profoundest biological and physical problems. The study of comparative or geographical zoölogy constitutes one of the essential factors of biological science, for without a true understanding of the general affinities of scattered groups of animals, our conception of the organic universe would be one of disjointed parts instead of a continuous whole. We know, in fact, little of a whole unless we comprehend its relation to its component parts, and *per contra*, we know little of a part unless we understand the relation it bears to the whole.

The subject of geographical distribution in its bearings on geology, whether considered in its broader sense as pertaining to groups, or in the more limited sense as pertaining to the individuals composing those groups, cannot be over-estimated. It is by the recurrence over broad or scattered areas of certain related animal types, and sometimes even over the most remote areas of identical specific forms, that the palæontologist is enabled to arrange and classify his strata. One single well-determined fossil will, in the absence of further data, frequently determine approximately,

and sometimes exactly, certain geological horizons, and although we cannot in most instances, as Prof. Huxley has forcibly pointed out, positively, or even approximately, correlate, as far as age is concerned, distantly separated formations, we can to a very great extent correlate the cosmical conditions under which the formations in question were deposited. The correct determination, therefore, of all organic remains is one of the greatest importance.

Unfortunately for the development of the science, the doctrine that identical specific forms cannot, or ought not, occur over widely separated areas has taken root in the minds of a few of the most eminent scientific investigators, the baneful effects of whose authority in relation to this special line of research, will be encountered by the student at almost every step in his investigations. The science of geographical palæontology, at least as far as the invertebrata are concerned, may be said to be in this country still in a state of infancy, a circumstance partly due to the limited number of workers in the field, and partly to the influences just stated.

I have endeavored in the following pages to summarize as nearly as possible the results obtained from a series of comparisons between the Eocene mollusca of Western Europe and that of the Southeastern United States, undertaken with the view of determining with a certain amount of precision the number of identical and very nearly related species. My comparisons were in a number of cases made between actual specimens, and those mainly determined in the localities to which they belong; where no specimens could be obtained I was compelled to content myself with the various analyses of the descriptions and figures afforded by the works of the most competent authorities. The result shows a far greater intimate relationship to exist between the two faunæ than one is led to suppose from an examination of the "Check List" prepared by Mr. Conrad for the Smithsonian Institution for 1866, where, in fact, only about five species are enumerated as common to the Eocene deposits of both shores of the Atlantic, viz.: *Ostrea* (*Gryphostrea*) *eversa*, Deshayes; *Cardita planicosta*, Lam.;? *Phorus* (*Onustus*) *extensus*, Sow.; *Hippocrenes columbaria*, DeFr.; and (?) *Voluta* (*Volutilithes*) *mutata*, Desh. In addition to these Conrad enumerated in 1833 ("Fossil shells of the Tertiary Formations," p. 34) the following: *Solarium patulum*, Lam.; *S. canali-*

culatum, Lam.; *Bulimus* (*Niso*) *terebellatus*, Lam.; *Sigaretus canaliculatus*, Sow.; *Calyptræa* (*Trochita*) *trochiformis*, Lam.; *Pyrula tricarinata*, Lam.; *Avicula trigona*, Lam.; *Cytherea erycinoides*, Lam.; *C. suberycinoides*, Desh.; *Corbis lamellosa*, Lam.; and *Fistulana elongata*, Desh., most of which on examination prove to be as well American as European forms. In the Appendix to Morton's Synopsis ("Synopsis of the Organic Remains of the Cretaceous Group," 1834) only six European species are recognized as occurring in the American formation: *Solarium canaliculatum*, Lam.; *S. patulum*, Lam.; *Bulimus terebellatus*, Lam.; *Cardita planicosta*, Lam.; *Corbis lamellosa*, Lam.; and *Fistulana elongata*, Desh. In the list published by Conrad in 1846 (Amer. Journ. Science, 2d ser. vol. i. p. 219), of the preceding enumerations only two species are retained as being "analogous" to transatlantic forms, *Cytherea Mortoni*, Con. (*Cytherea erycinoides*, Lam.; and *C. suberycinoides*, Desh.) and *Avicula limula*, Con. (*A. trigona*, Lam.), but in addition we have five new ones catalogued: *Cardita Blandingi*, Con. (*C. acuticosta*, Lam.); *C. rotunda*, Lea. (*C. asperula*, Desh.); *Cardium Nicolleti*, Con. (*C. semigranosum* [—*granulatum*], Sow.); *Turritella Mortoni*, Con. (=?); and *Rostellaria laqueata*, Con. (*R. fissurella*, Lam.). Finally, all species considered identical prior to 1866 are rejected as such with one exception (*Cardita planicosta*) in the Smithsonian List. The reasons for so doing, which, in the majority of cases, I believe, are not stated, appear to me incomprehensible.

In the introduction to his "Contributions to Geology," 1833, p. 19, Mr. Lea states that he is "not perfectly satisfied that a single species is strictly analogous to those from the Eocene Period of Europe", but in a note (pp. 207, 208) makes the following comparisons: *Pasithea umbilicata*, Lea, with *Bulimus terebellatus*, Lam.; *Venericardia rotunda*, Lea, with *V. squamosa*, Lam.; *Pectunculus obliqua(uus)*, Lea, with *P. nanus*, Desh.; *Ostrea divaricata*, Lea, with *O. flabellula*, Lam.; and *Solen Blainvillii*, Lea, with *Solen effusus*, Lam.

The list herewith appended, and which it is my intention to complete at a future date, will, I trust, increase our knowledge on the interesting questions of relationship and geographical distribution.

Ostrea divaricata, Lea. "Contributions to Geology," p. 90, pl. 3, fig. 69.

O. sellæformis, Conrad, *pars* ?

This oyster is referred without doubt both by Nyst ("*Coquilles et Polypiers Fossiles*," 1843, p. 323) and Giebel (*Repertorium to Goldfuss' "Petrefacta Germaniæ*," 1866, p. 41) to the *O. flabellula* of Lamarck, which is a very variable, and one of the most widely diffused forms of fossil oyster. It is cited by D'Orbigny (*Prodr. de paléon.*) as occurring at Claiborne, Ala., and by Deshayes (*Animaux s. vert., bassin de Paris*) also at Cutch in India and Cairo in Egypt.

Pecten Deshayesii, Lea. Contr. p. 87, pl. 3, fig. 66

(*et P. Lyelli*, acc. to Conrad ?).

This *Pecten* is referred with but little doubt by Nyst (*Coqu. et Pol.*, p. 288) to *P. opercularis*, Lamk., which species, however, belongs to a much more recent period than the Eocene of Alabama. On the assurance of identity Nyst in 1836 founded upon a new Belgian *Pecten* the specific name of *Deshayesii*, but his fossil must be carefully distinguished from the American one in question. Having seen but one example of Lea's species I am unable to make the proper comparisons.

Cardita rotunda, Lea. Contr. p. 70, pl. 2, fig. 48, as *Venericardia*.

This species very closely resembles the *Cardita imbricata* of Lamarck, to which, in the absence of specimens, it is with some hesitation referred by Nyst (p. 209), and also by Bronn (*Index Palæontologicus*, I. 226). The only difference that I could detect between the two species, on an examination of numerous specimens from Grignon, France, and Claiborne, Ala., was that in the *C. imbricata* there was a tendency in the ribs of the posterior slope to become crowded. As some specimens of both forms, however, could not readily be distinguished from each other, I believe this circumstance to be mainly accidental, and therefore consider the *C. rotunda* as certainly nothing more than a mere variety of *C. imbricata*.

Cardita planicosta, Lamk.

This species of *Cardita*, which is so extensively distributed over the Eocene deposits of Europe, is certainly identical with the similar forms of *Cardita* found in the same formation of the United States. Lea (Cont. p. 19) states that according to his observations the American species differs from the European in the num-

ber of its costæ (about 29 instead of 34), but on an examination of numerous French specimens I found the number to be frequently only 29.

Cardium Nicolleti, Conrad. J. A. N. S., viii. p. 190.

This *Cardium* will, I believe, on close examination prove to be the *C. semigranulatum* of Sowerby (Mineral Conchology, II. p. 99). It does not differ from a species of *Cardium* in the Academy Museum marked "*C. semistriatum*, London Clay," but as the *C. semistriatum*, Deshayes, differs in the arrangement of its granulated striæ from the specimen in question marked *semistriatum*, and as the last agrees in characters with the description accorded by Sowerby to *C. semigranulatum*, it is highly probable that the names have been simply reversed.

Corbis (Gafrarium) lirata, Con. A. J. Science, I., 2d ser. p. 401.

This species was originally described by Conrad as the *C. lamellosa*, Lam., with the characters of which it was found to agree in all essential respects. I have been unable to note any material difference between the two species in question, and do not hesitate, after an examination of a number of specimens representing Lamarck's type, to unite the two under the one specific name of *lamellosa*.

Limopsis ellipsis, Lea. Contr. p. 78, pl. 3, fig. 56, as *Pectunculus*.

This species closely resembles in general characters the *L. (Stalagmium?) Nystii* of Galeotti, from which it mainly differs in the greater number of teeth both in the anterior and posterior series, the number in each series rarely falling below twelve.

Limopsis aviculoides, Con. Foss. Shells of Tert., p. 39, as *Pectunculus*. (*Pectunculus obliquus*, Lea.)

Bronn (*Index Palæont.*, ii., p. 936) allies this species with the *Limopsis nana* of Deshayes, from which it differs very materially in the greater elevation of the umbones and cardinal region. Nyst considers it as closely related to *Trigonocælia auritoides*, Gal., but the obliquity in form is much greater in the American species. It differs from the *Limopsis aurita* of Sassi (*Arca aurita*, Brocchi, "*Conchiologia Fossile Subapennina*," ii., p. 485) in having a crenulated margin.

Corbula oniscus, Con. A. J. Science xxiii., p. 341.

C. Murchisonii, Lea.

This species is referred by Bronn (*Index Palæont.*) to the *C. rugosa* of Lamarck, to the description of which, as given by Des-

hayes ("Coquilles Fossiles," i., p. 51) it agrees in all essential respects. As in the case of the French species it frequently resolves itself into two layers, the inner of which may at first sight be readily mistaken for a new species (*C. bicostata*? Nyst). The *C. gibba*, Olivi, which, according to Nyst, is the equivalent of *C. Murchisonii*, Lea, is a Miocene(?), Pliocene, and living species. I have been unable to institute direct comparisons for want of specimens.

Cytherea Mortoni, Con. J. A. N. S., vii., p. 150.

This species of *Cytherea* was originally confounded by Conrad with the *C. erycinoides*, Lam. (Foss. Shells of Tert., 1832, p. 34), but a close examination shows the latter to be comparatively more elevated, and its ribs to be proportionately much more robust.

Trochita trochiformis, Lea. Contr., p. 96, pl. 3, fig. 76.

This species, described as new by Mr. Lea in 1833, is synonymous with *T. (Calyptæa) trochiformis* of Lamarck (*Trochus apertus*, Brand.).

Cylichna galba, Con. Foss. Shells of Tert., p. 34, as *Volvaria*.

(*Bulla St. Hillairii*, Lea.)

This species appears to me to be erroneously referred by Bronn to *Bulla constricta*, Sow. (Miner. Conch., vol. v., p. 96), as Sowerby's species has no fold on the columella, at least no mention is made of it in his description, nor does it appear in his figure. Our species appears to be closely allied to if not identical with *Bulla Brocchii*, Bronn, an Italian (Miocene?) species (Brocchi, Conch. Foss. Subapenn., ii., p. 277, as *Bulla ovulata*? Lam.).

Cyprædia fenestralis, Con. Proc. A. N. S., vii. p. 262.

This appears to me to be identical with *Cypræa (Luponia, Gray) elegans* of DeFrance, from which I cannot discover any distinguishing characters. Conrad states that no mention is made by Deshayes in his description of the fossil of the Paris basin of "microscopical regular lines," but an examination of a specimen in the Academy collection shows them to be present.

Tornatella (Actæon) pomilia, Con. Foss. Shells of Tert., p. 45.

Actæon punctatus, Lea.

Monptygma elegans, Lea.

= *Tornatella inflata*? Férussac.

Tornatella (Tornatellæ) bella, Con.

A comparison of this species with Sowerby's description and

figure of *Actæon simulatus* (*Bulla simulata*, Brander) leaves no doubt that the two species are identical. Nor does a comparison of actual specimens, from Alabama and Barton, England, show any varying characters.

Fusus (Bulbifusus) inauratus, Con. Foss. Shells of Tert., p. 29.

This species is more closely allied to *F. bulbiformis*, Lam., than to *F. ficulneus*, Lam., to which last it is doubtfully referred by Bronn (p. 512). It differs from the former, however, in having the canal more produced, in the whorls being strongly subangulate above, and in the superior ones being crenulated on their basal margins.

Pyrula penita, Con. Foss. Shells of Tert., p. 32.

P. tricarinata, Con.

P. cancellata, Lea.

P. elegantissima, Lea.

I am disposed to consider the above as identical with *Pyrula nexilis*, Lam. (and var. *P. tricarinata*, Lam.), which is a most variable fossil. Both American and European forms appear in the most diverse stages of convexity and angulation. Conrad, although he subsequently separated the transatlantic forms into two distinct species, states (Foss. Shells of Tert., 2d ed., p. 39), "that the variety is not distinct I am assured by comparison of many specimens." I am also inclined to unite with the above the *P. (Fusus) Mississippiensis*, Con.

Oliva bombylis, Con. Foss. Shells of Tert., 2d ed., p. 42.

(*O. constricta*, Lea.)

Differs from the *O. mitreola*, Lam., in having the plications at base less numerous and somewhat less regular, and in wanting the upper of the two impressed revolving lines on the body whorl. In the absence of the line it agrees more closely with *O. nitidula*, which was separated by Deshayes from the *O. mitreola* as a distinct species. The *O. Brocchii*, Bronn (*Voluta ispidula*, L. var. Brocchi "*Conch. Foss. Subapenn.*," ii., p. 315, pl. iii., fig. 16), which is as well a Miocene, and perhaps even living species (Bronn, iii., p. 481), appears to be very clearly related to our species.

Cancellaria tortiplica, Con. Am. Journ. of Conchol., vol. i., p. 211.

On an examination of specimens of this species and *C. evulsa*, Brander (from Barton, England) I find the two to be most intimately allied to each other, the main difference being that the *C.*

tortiplica is somewhat more slender and elevated. As this may be only an accidental feature in the few examples which have come under my notice, I feel but little hesitation in uniting the two as one species. Bronn and Nyst (p. 477) refer with some doubt the *C. parva* of Lea to Brander's type, but this diminutive Alabama species has only two plaits on the columella, and is destitute of varices.

Niso umbilicata, Lea. Contr., p. 103, as *Pasithea*.

Niso terebellatus, Lamk.

I have been unable to detect the slightest difference between specimens obtained from both species.

Sigaretus canaliculatus, Sow. Min. Conch., iv., p. 115.

This shell is mentioned by Conrad (Foss. Shells of Tert., 2d ed., p. 34) as occurring at Claiborne, Ala. It is probably identical with *S. declivus* and *S. bilix*, Con., which differ among themselves about as much as they do from the European species.

Solarium ornatum, Lea. Contr., p. 120.

This species is placed without doubt by Bronn (ii., p. 1153) as synonymous with *S. canaliculatum*, Lam. The description and figures as given by Deshayes (*Coqu. Foss.*, ii., p. 221) answer perfectly to the American species, and I feel no doubt but that an examination of specimens of both species will prove their identity. The *S. canaliculatum* is mentioned by Conrad (Foss. Shells of Tert., 2d ed., p. 34) as occurring in the Alabama Eocene deposits.

Pleurotoma denticula, Bast. Descrip. Géol. du Bass. Ter. Sud-ouest de la France, 1825, p. 63.

On a comparison of specimens of the *P. nodo-carinata*, Gabb (J. A. N. S., 2d series, vol. iv., p. 379), with the exhaustive analysis of the above species as given by Mr. F. E. Edwards in his "Monograph of the Eocene Mollusca" of England (Reports of the Palæontographical Society), I feel no hesitation in including it among the numerous varieties of Basterot's species. No mention is made by Gabb of a division of the central crenulation into a double series, but at least some of the specimens deposited in the Academy Museum, and marked with his specific name, show this feature distinctly. The *P. denticula* is a very widely distributed species of *Pleurotoma*, its range in Europe extending from England through Belgium (Nyst, "*Coqu. et Pol. Foss.*" p. 526) and France (Basterot, *sup.*; Grateloup "*Conchyl. Foss. des Terr. Ter.*,"

atlas, pl. 11 (20) fig. 8) to North Italy (Bellardi "*Monog. Pleurot. Foss. del Piem.*," *Memorie della Reale Accademia di Torino*, 2d ser., vol. ix., p. 576). This species corresponds probably to some extent with Sowerby's *P. comma*. Unquestionable specimens of *P. denticula* from the Eocene of Alabama are to be found in the American Museum of Natural History of New York.

Mesostoma rugosa, nob. Proc. A. N. S., Oct. 1879.

This species might readily be mistaken for the *M. grata*, Desh., of the Paris basin, from which it differs only in the greater number of its revolving ridges.

Melania Claibornensis, nob. Proc. A. N. S., Oct. 1879.

This diminutive *Melania*, which to my knowledge constitutes the only essentially fresh-water gasteropod found to the present time in the Claiborne marine formation, cannot in its characters be readily distinguished from the *M. mixta*, Desh., of the Paris basin (description and fig. in Desh. "*Animaux s. vert.*"). Having observed but one specimen, and not wishing to definitely deduce its affinities from the characters drawn from a single example, I have provisionally applied to the American shell the specific name which it bears above.

A close comparison of the Eocene mollusca of the east and west Atlantic shores will, I am confident, reveal a larger number of identical forms than those enumerated in the above list. The *Naticidæ* and *Pectunculidæ*, two families requiring acute revision, appear more especially to be intimately related in their specific forms.